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ABSTRACT

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Objective: Twenty-two million Americans or roughly 8% of the population are hearing impaired. This affects more than just the ability for one to hear. In the last three decades, younger Americans have shown a sharp increase in hearing impairment. Hearing loss affects social and emotional well being and thus has the ability to decrease one's quality of life. This study was designed to examine the association between smoking, workplace chemical exposure, and hearing loss.

Methods: This cross-sectional population-based study was conducted in an occupational health clinic setting in Virginia. The study population consisted of employees from local businesses who visited the clinic during the period of 1/1/03 to 1/1/05 for pure tone audiometry. Chart reviews supplemented by telephone interviews were conducted to extract data for analysis. All study subjects were eligible to participate except for those who were unable to communicate due to a language barrier. Prevalence and crude prevalence ratios were calculated. Adjusted prevalence ratios and prevalence odds ratios were calculated using Cox and logistic regression models. Data entry and statistical analysis were accomplished with the SPSS Data Builder and the SPSS 13.0 statistical software. SAS statistical software was also used for a portion of the statistical analysis.

Results: In a Cox regression model controlling for many potential confounding factors (age, race, smoking, chemical exposure, military service, as well as others) cigarette smoking was not associated with hearing loss PR(95% CI), 1.0 (0.7, 1.3). Similarly, exposure to chemicals was not associated with hearing loss 1.1 (0.7, 1.6).

Conclusion: This study did not find an association between cigarette smoking and hearing loss and exposure to industrial chemicals and hearing loss in persons who worked in a noisy occupational environment.

INTRODUCTION

Hearing loss is a growing problem in society, with increased estimates of incidence in younger ages predicted. According to the National Academy on an Aging Society, twenty-two million Americans have impaired hearing, amounting to approximately 8% of the population (1). Hearing loss affects more than just the ability for one to hear. It is known that hearing loss affects the quality of life of the hearing impaired. It affects the social aspects of life as well as emotional well being, and can often lead to depression. In a 1992 Health and Retirement Study (1), researchers found that people with hearing loss expressed greater dissatisfaction with friendships, family life, health, and financial situations.

About 43% of people with hearing loss are at or above the age of sixty-five. This age group is more likely than any other to suffer from hearing loss. This is somewhat due in part from a condition known as presbycusis. This is a gradual, age-related reduction in recognition of higher frequency sounds. It is an accepted cause of hearing loss in the elderly. However, results of some studies of rural African tribes conducted in the 1960's showed no decline in hearing sensitivity with age (7). This suggests that other factors may play a role in the development of hearing loss such as genetics, lifestyle factors, medical treatments, environmental/occupational exposures, as well as others.

Older persons make up the largest proportion of the hearing impaired. However, among the population of people ranging from 18-64, more than five million have reported some degree of hearing loss. Analysis of data from the 1994 National Health Interview Survey of Disability showed 29% of the hearing impaired were 45 to 64 years of age and 23% were 18 to 44 years of age (1). Another 5 % were from birth to seventeen years of age. In looking at the gender of the hearing impaired, 61% were found to be male and 39% female. In regards to ethnicity, 91% of the hearing impaired were found to be white, while 6% were black and 3% claimed another ethnic origin.

Although hearing loss is widely associated with aging, over the last three decades there has been a sharp increase in the number of younger Americans that are hearing impaired. Analysis of data from the National Health Survey revealed from 1971 to 1990, that hearing impairment escalated 17% in the 18-44 age group and 26% in the 45-64 age

group (5). In an Alameda County study which looked at over 5000 men and women over three decades of time, researchers found an even sharper increase in hearing impairment for those 50 and older. The rate of hearing impairment in this age group increased more than 150% from 1965 - 1994 (6). The study concluded the data did not pinpoint the cause, but identified several risk factors including environmental and occupational noise.

While presbycusis is the most common cause of hearing loss, the second most common is noise-induced hearing loss. This condition occurs from sudden bursts of loud noise or exposure to loud noise over extended periods of time. The prevalence of this type of hearing loss is expected to rise secondary to: exposures of trendy loud music, powerful stereo equipment, use of headphones, as well as increased traffic, lawn mowers, power equipment and work environments.

Noise-induced hearing loss often occurs while on the job, however there are other forms of hearing loss in the work environment. Sources of this type of hearing loss in the workplace include continuous exposure to noise in excess of 85 dB, blunt head injury, and exposures to ototoxic substances. Workers who are being treated with potentially ototoxic medications such as aminoglycoside antibiotics, loop diuretics, antineoplastic agents, and aspirin are at greater risk for hearing loss when exposed to noise. The combination of the medication and noise can induce more loss of hearing than either by themselves. Other types of exposures in the workplace can also lead to hearing loss. Exposures to heavy metals including arsenic, cobalt, lead, and lithium have a known ototoxic potential. Certain chemicals and industrial solvents also may be ototoxic, such as cyanide, benzene, iodine, carbon monoxide, styrene and toluene (23).

Occupational hearing loss may be characterized many ways. It may be partial or total, unilateral or bilateral, conductive or sensorineural, or a mixture of both conductive and sensorineural. Conductive hearing loss is a result of dysfunction of the external or inner ear. Blunt trauma, penetrating head injuries, and explosive or thermal type injuries are all examples of this type of hearing loss. Sensory hearing loss results from the damage and loss of hair cells in the organ of Corti resulting in deterioration of the cochlea.

Although there are several ways of acquiring hearing loss in the workplace, noise exposure ranks among the highest. It is a well-known fact that noise is the most common

occupational exposure in the world (4). An estimated 600 million persons worldwide are exposed to noise as they work. It is estimated that 6-10 million workers in the United States are exposed to industrial noise (3). It is also a well-known fact that noise exposure contributes to hearing loss.

Noise is generally thought of as the major occupational exposure that contributes to hearing loss. However, since the adoption of the OSHA Noise Standard in 1971, prevalence rates of hearing loss are higher than one would expect. In fact, even after an amendment to the standard in 1983 requiring institution of hearing conservation programs in industry, the prevalence rates of hearing loss continue to be elevated. This leads to speculation that hearing loss is related to other risk factors. It is postulated that those factors include, but are not limited to, chemicals, solvents, and cigarette smoking.

Current studies have shown that along with noise, chemical and solvent exposure also contribute to hearing loss. In fact, Morata, et al. in 1997 (24) reported findings that suggest combined effects of noise and chemical exposure may actually increase the noise effect on hearing. Sliwinska-Kowalska, et al. duplicated these results in a controlled study done on a group of dockyard workers (9). Results showed the probability of developing hearing loss was over three times higher than controls with noise exposure and almost five times higher in the group exposed to noise and solvents.

Noise and chemical/solvent exposures are two of the most common risk factors for hearing loss. However, research has shown others risk factors as well. Use of tobacco, having high blood pressure or poor lipid metabolism and the use of pain-alleviating medication have also been investigated for their association with the risk of hearing loss (10).

Several studies have been conducted and have shown conflicting evidence regarding tobacco smoking and hearing loss. Some studies conducted observed excessive sensory neural hearing loss (SNHL) due to smoking, while others did not find such a correlation. In a meta-analysis conducted by Nomura, et al., (12) where fifteen studies were reviewed, results showed favor towards the hypothesis that smoking *could* cause hearing loss. In the analyzable studies, the risk ratios with 95% confidence intervals for hearing loss in smokers were 1.33(1.24, 1.44) for cross-sectional studies, 1.97(1.44, 2.70) for cohort studies, and 2.89(2.26, 3.70) for case-control studies, respectively. In the

Epidemiology of Hearing Loss Study (7) conducted in 1998, results showed that smokers were 1.69 times more likely to damage their hearing ability. According to the study, 25.9 percent of smokers in the 48 – 59 age group were suffering from hearing loss, compared to 16.1 percent among non-smokers and 22.7 percent of ex-smokers. The same trend was found in the older age groups. In a more recent study where serum cotinine levels were measured (25), no correlation between smoking and hearing loss was observed in any of the categories of smokers, non-smokers or ex-smokers.

While hearing loss is a debilitating chronic condition that affects many in our society, hearing trouble that occurs before the loss of hearing can also be debilitating as well. Changes in the inner ear may cause sudden, rapid hearing loss or dizziness and difficulty with balance that increases the chance for falling. Tinnitus is also a condition that can also be induced by noise exposure. It is often referred to as "ringing in the ears". However, other perceptions of the sound include "buzzing, hissing, whistling, and humming" (26). The impact from tinnitus can range from incidental to severe. For those affected, problems have been documented with regard to emotional health, hearing, sleep and concentration as well as induction of fear, frustration, anger and irritability (26). Prevalence of tinnitus is such that in the 1990 Hearing Supplement of the National Health Survey, questions were designed to extract data regarding "noises" heard in the ears. Other questions that followed sought to gain information concerning the frequency, degree of botheration, and age of onset regarding the noises.

Noise is defined as loud, discordant or disagreeable sound according to Webster. While normal hearing for adults, is generally defined as hearing thresholds that are between 0 and 25 decibels from 250 – 8000 Hertz, it is important to remember that there are no clear, set guidelines for hearing as there are for human temperature or blood-pressure.

The purpose of this study is to assess for an association of hearing loss in smokers and non-smokers who are exposed to noise and chemicals in their work environments. A subset study will also be conducted looking at 417 study participants. Of those, 104 participants work in an environment with known exposure to chemicals and solvents used in the printing industry. The other 313 participants work in an environment with noise exposure and no known exposure to chemicals or solvents.

METHODS

This cross-sectional study was conducted in an occupational health clinic in Virginia. The study population was derived from the occupational health clinic patient base. The eligible population comprised of all patients who had pure tone audiometry performed in the clinic during the time frame of 1/1/03 to 1/1/05. Using the StolaSystem software utilized by the clinic, a list of all clients who met the criteria was compiled (N=1350). A chart review was performed and the audiograms performed between 1/1/03 and 1/1/05 were entered in the database (N=1132). In the process of the chart review, the total number of available study subject audiograms decreased in number from 1350 to 1132. This was mainly due to a large number of study subjects being duplicated, as some are involved in annual exams secondary to hearing conservation programs where they are employed.

The study population consisted of male and female workers employed in forty-three companies in and around the City of Richmond and both Chesterfield and Henrico counties. All workers were included in the subject pool. Study subjects received audiometric testing for pre-employment baseline physical exams, or to fulfill requirements of their employers OSHA mandated Hearing Conservation Program or for failure to pass the "whisper test" on an annual medical exam required by the Federal Motor Carrier Safety Administration for a commercial driver's license. Participants were asked to fill out brief hearing questionnaires prior to being placed in the hearing booth for testing. Data for the study was extracted from the hearing questionnaire as well as chart review.

All study subjects underwent puretone air-conduction audiometry in an IAC Model 250 hearing booth. A MicroAudiometrics Microlab model audiometer measured hearing acuity at the frequencies of 0.5, 1, 2, 3, 4, 6, and 8 kHz. Staff members who are certified occupational hearing conservationists performed the audiometric testing in one of two clinics. Both Microlab audiometers underwent exhaustive annual calibrations and biological calibrations were performed daily in each clinic. For the purpose of this study, hearing loss is defined as a hearing threshold greater than 25 dB in any of the hearing frequencies (500 – 8000 Hz).

Tobacco use was determined by chart review, as the audiometric questionnaire did not request any information on smoking history. Information, which was unavailable after the chart review, was collected via a brief telephone interview. Either a "yes" or a "no" answer determined smoking status.

Four of the companies where study participants are employed are known printing facilities. They have known exposure to both chemicals and solvents that are commonly used in the printing industry. Some of the chemicals are Sulfuric, Hydrochloric, Nitric, and Chromic Acid. Solvents found in each of the facilities include Acetone, Naphtha, and Butyl Acetate. According to the previous published studies, exposure to both chemicals and solvents in the presence of noise have been shown to contribute to hearing loss (9, 24).

Statistical analysis of the data was performed using SPSS 13.0 (SPS, Inc.). The dependent variable for the analysis was hearing loss. The analysis focused on factors that may contribute to hearing loss such as noise exposure, family history of hearing loss, military service, as well as others. A logistic regression model was used initially, but secondary to the prevalence of hearing loss in both smokers and non-smokers being above 45 percent, the effect estimate was being overestimated, making analysis difficult. As a result, the Cox Proportional Hazards model was utilized resulting in a direct estimate of the prevalence ratio. For statistical analysis, the Cox Proportional Hazards model was then utilized to evaluate the odds of having hearing loss associated with smoking while adjusting for age, sex and other potential confounders. After the analysis was complete, SAS (SAS Institute Inc, Cary, N.C.) was used to correct the interval estimates of the prevalence ratios secondary to this correction factor not being available in the SPSS software program.

RESULTS

Characteristics of Study Subjects

Out of the 1132 study participants, 11.4% were female while 88.6% were male. The mean age of the study participant was 41.5 with a standard deviation of 10.8 years. The study population consisted of 37.9% Black persons, 47.8% White persons, 11.9% Hispanic persons and 2.4% reported another race. The age of the study population was

fairly evenly distributed with 17% less than 30, 25.8% between 30 and 39, 31.5% between 40 and 49, and 25.7% greater than 50 years old. Noise in the ears (tinnitus) was reported in only 107 of the study participants, but out of those, 97 exhibited hearing loss. Family history of hearing loss was reported in 77 of the participants with 49 of those exhibiting hearing loss. Information on smoking status was unavailable in 11.1% of the population, but 39.8% reported that they smoked and 49.1% reported that they did not. Table 1 presents more of the descriptive characteristics of the participants of the study.

The prevalence of hearing loss in males was 55.6%, which was about twice that of the female prevalence of 29.5%. When looking at the race of the study participants, Whites (55.1%) had a higher prevalence of hearing loss than Blacks (46.9%), which was consistent with the literature. However, Hispanics had the highest prevalence at 60.7% with Others at 55.6%. This could be partially attributed to the small numbers and the types of known jobs they performed. When looking at the crude and adjusted rates (Table 6) race did not play a significant factor in the association of hearing loss.

Smoking status was reported as a yes or no. Prevalence of smoking was 51.9% among the study participants. Non-smoking prevalence was 50.8%. As shown in Table 3, age was a strong determinant of hearing loss. In the <30 age group, prevalence of hearing loss was 20.3% (95% CI 15.0, 26.8). In the 30-39 age group, prevalence increased to 34.2% (95% CI 28.9, 40.0). In the 40-49 age group, results significantly increased to a prevalence rate of 60.8% (95%CI 55.5, 65.8). And finally, in the 50+ age group results were also again increased at an 82.5% prevalence (95% CI 77.5, 86.6). Likewise, when looking at the crude and the adjusted prevalence ratios (Table 6) as age increased, the prevalence ratios also increased.

Prevalence ratios were calculated and reported in Table 5. Significance was noted in the following variables: **noise in the ears** (tinnitus) PR 1.9 (1.5, 2.3), **military service** PR 1.2 (1.0, 1.4), **measles** PR 1.5 (1.2, 1.7), and **mumps** PR 1.4 (1.2, 1.7). However, once the variables were placed in a regression model, most lost their significance.

After looking at many variables that are known to be associated with hearing loss, the findings of the regression model did not yield the expected results. Out of all the variables, tinnitus was the only variable that was significant in the incidence of hearing loss. Smoking did not show a significant risk for hearing loss in either the crude or the

adjusted prevalence ratios (Table 6).

Table 7 outlines the data found in the subset study looking at the incidence of hearing loss when exposed to chemicals. The results were congruent to the main study in that males were found to have a greater risk than females. Race findings were not shown to be significant in either the crude or the adjusted prevalence ratios. Age still remained a significant finding in the incidence of hearing loss in both the crude and adjusted ratios. Tinnitus was still the only significant variable in the prevalence of hearing loss in both crude and adjusted ratios. Interestingly, chemical exposure was mildly significant in the crude calculations, but lost its significance in the adjusted prevalence calculations.

DISCUSSION

Hearing loss is a large public health problem with over twenty-two million Americans reporting impaired hearing (1). There is strong evidence to suggest that noise is a major contributor to hearing loss (3). Age is also associated with hearing loss and is documented as well, however from 1971 to 1990 the incidence of hearing impairment has increased in the lower age groups (5). Smoking has been shown to contribute to hearing loss (7) in some studies and inconclusive in others (25). It is suggested that chemical exposure can be an accelerator on hearing loss in the presence of noise (24). Using a multivariable regression model that controlled for many factors, this study failed to show an association between smoking and hearing loss even in the presence of chemical exposure.

The first model of statistical analyses was performed using the logistic regression model. Results of the logistic regression showed higher than the average expected results. This was mainly due to the high prevalence of hearing loss in the general study population. After many data were analyzed, a decision was made to move toward a Cox Proportional Hazards model. In the Cox regression model, all study subjects were given a ten-year time to event. The results yielded lower prevalence ratios yet no increased incidence of statistical significance was noted in any of the variables studied.

In looking at the results regarding gender, males were found to have about twice the risk of hearing loss than females. These findings are congruent with a review of the literature. Looking at the race of the study subjects, whites were at greater risk than blacks, but not more than hispanics. This could be attributed to the low number of hispanics in the study population and the types of jobs they performed, which placed them at higher risk for hearing loss. However, after the multivariable regression model, race was no longer significant in predicting the risk of hearing loss. In the age category, the results were congruent with previous studies. Using the 19-30 age group as the referent group, as hearing loss is least likely to occur in this age span, 31-40 year olds were almost twice as likely to have hearing loss. The 41-50 year olds were three times more likely to have hearing loss, and being 50 and older gave better than four times the risk for hearing loss (Table 5). Even after the multivariable regression analysis, age was found to be a significant predictor of hearing loss in this study.

The literature has shown that tinnitus is a condition that can also be induced by noise exposure, with the impact ranging from incidental to severe (26). The prevalence rate of tinnitus in the study population was 90.7% with 95% C.I. 83.1, 95.2. Out of 107 study subjects claiming they experienced a noise in their ears, 97 showed hearing loss in at least one of the hearing frequencies. In the regression model, the crude prevalence ratio was 1.9 with 95% C.I. 1.5, 2.3, and the adjusted prevalence ratio was 1.5 with 95% C.I. 1.2, 2.0. These findings are consistent with the literature in that hearing noises in the ears affects the hearing status of an individual.

Even though the literature reports family history of hearing loss, prior military service, exposure to guns, noisy hobbies and smoking as risk factors for hearing loss, they were not found to be significant predictors after the multivariable regression analyses.

A subset analysis was performed on a selected sample of the study population. The exposed to chemical group consisted of 104 employees of printing-type businesses. The unexposed to chemical group consisted of 313 employees of other types of business where noise exposure was common but chemical exposure was not. Many of the results regarding gender, race, age and tinnitus were replicated. Chemical exposure did show a 30% increase in hearing loss in the crude results, but lost its significance in the adjusted

results (Table 7). Smoking did not show any significance in the risk of hearing loss in the presence of chemicals in this analysis.

CONCLUSION

The results of this study support previous research findings in the association between hearing loss and gender, age, and tinnitus. Unfortunately, no association was seen regarding hearing loss and smoking, whether or not smokers were exposed to chemicals.

The findings should be interpreted in the context of the study's strengths and weaknesses. Even though the sample size was relatively small when compared to NHANES data sets, the data was "real-life", gathered from the employees of local businesses, where the results can be used in education of the employees in promotion of hearing conservation.

Limitations of the study include the fact that the measuring characteristic of the variable of interest was general instead of quantitative. Smoking should be looked at in a manner of cigarettes smoked per day and for how long, as in pack-year history. It could also be assessed by measuring serum cotinine levels of the study participants as in the study conducted by Nondahl et al. (25). This would give a more specific picture of smoking status for analysis and a dose-effect could be assessed and measured.

Noise exposure was also a factor in the study that could be improved upon. For instance, noise map data of the companies could be entered into the database showing dosimeter measurements of the employees. This would quantify the amount of noise that the employee was exposed to and for how long. In the same respect, chemical exposure could also be measured differently, allowing for quantification of the dose of chemical exposure.

In conclusion, with hearing loss increasing in society in lower ages than ever, more studies should be conducted to determine if smoking is indeed a risk factor for hearing loss, as prevalence rates of smoking are also high in younger citizens. The future health status of the inhabitants of the United States depends on the research of today.

TABLE 1. Characteristics of Study Subjects

VARIABLE	TOTAL		HEARING LOSS		NORMAL HEARING	
	N	%	N	%	N	%
Gender						
Male	1003	88.6	558	93.6	445	83
Female	129	11.4	38	6.4	91	17
Unknown	0					
Race						
Black/African American	429	37.9	201	33.7	228	42.5
White	541	47.8	298	50	243	45.3
Hispanic	135	11.9	82	13.8	53	9.9
Other	27	2.4	15	2.5	12	2.2
Unknown	0					
Age						
<30	192	17	39	6.5	153	28.5
30-39	292	25.8	100	16.8	192	35.8
40-49	357	31.5	217	36.4	140	26.2
50+	291	25.7	240	40.3	51	9.5
Unknown	0					
Currently Experiencing Noise in the ears						
yes	107	9.5	97	17.1	10	2
no	969	85.6	470	82.9	499	98
Unknown	56	4.9				
Currently Experiencing Dizziness						
yes	22	1.9	15	2.7	7	1.4
no	1047	92.5	544	97.3	503	98.6
Unknown	63	5.6				
Currently Experiencing Pain in the Ears						
yes	15	1.3	12	2.2	3	0.6
no	1042	92	544	97.8	498	99.4
Unknown	75	6.6				
Currently Experiencing Sudden Rapid Hearing Loss						
yes	15	1.3	12	2.2	3	0.6
no	1041	92	546	97.8	495	99.4
Unknown	76	6.7				
Currently Experiencing Ear Infection						
yes	30	2.7	22	3.9	8	1.6
no	1031	91.1	536	96.1	495	98.4
Unknown	71	6.3				
Family History of Hearing Loss						
yes	77	6.8	49	9.3	28	6.2
no	904	79.9	479	90.7	425	93.8
Unknown	151	13.3				
Military Service						
yes	290	25.6	169	31.1	121	24.8
no	742	65.5	375	68.9	367	75.2
Unknown	100	8.8				

TABLE 1. Characteristics of Study Subjects **Con't**

VARIABLE	TOTAL		HEARING LOSS		NORMAL HEARING	
	N	%	N	%	N	%
Use of Hearing Protection in High Noise Areas						
yes	737	65.1	405	83.5	332	81
no	158	14	80	16.5	78	19
Unknown	237	20.9				
Past Medical History of Childhood Diseases						
yes	309	27.3	157	26.3	152	28.4
no	822	72.6	439	73.7	383	71.6
Unknown	1	0.1				
Measles						
yes	275	24.3	190	32	85	15.9
no	854	75.4	403	68	451	84.1
Unknown	3	0.3				
Mumps						
yes	225	19.9	156	26.4	69	12.9
no	902	79.7	435	73.6	467	87.1
Unknown	5	0.4				
Chicken Pox						
yes	543	48	274	46.3	269	50.5
no	582	51.4	318	53.7	264	49.5
Unknown	7	0.6				
Meningitis						
yes	8	0.7	5	0.8	3	0.6
no	1124	99.3	591	99.2	533	99.4
Unknown	0					
Past Medical History of Large Doses of Antibiotics, Quinine or Aspirin						
yes	51	4.5	35	6.7	16	3.5
no	937	82.8	491	93.3	446	96.5
Unknown	144	12.7				
Past Noisy Employment						
yes	495	43.7	274	51.8	221	46.2
no	512	45.2	255	48.2	257	53.8
Unknown	125	11				
Past Exposure to Guns						
yes	415	36.6	233	44	182	38
no	593	52.4	296	56	297	62
Unknown	124	11				
Participation in a Noisy Hobby						
yes	215	19	98	18.3	117	24.1
no	806	71.2	438	81.7	368	75.9
Unknown	111	9.8				
Smoking Status						
yes	451	39.8	234	45.3	217	44.3
no	555	49.1	282	54.7	273	55.7
Unknown	126	11.1				

TABLE 2. Characteristics of Study Subjects by Type of Employer

VARIABLE	TOTAL		HEARING LOSS		NORMAL HEARING	
	N	%	N	%	N	%
Employer						
Alcan Lawson Mardon	16	1.4	4	0.7	12	2.2
Alstom Power	3	0.3	1	0.2	2	0.4
Alcoa	166	14.7	85	14.3	81	15.1
AtlanticIndustrial	5	0.4	2	0.3	3	0.6
ATMI	1	0.1	0	0	1	0.2
AW Bennett	7	0.6	5	0.8	2	0.4
Cap.Reg.Airport	90	8	41	6.9	49	9.1
Carter Lumber	5	0.4	5	0.8	0	0
Central Parking	1	0.1	1	0.2	0	0
Chesterfield Co.	35	3.1	22	3.7	13	2.4
Church& Dwight	39	3.4	15	2.5	24	4.5
City of Hopewell	12	1.1	2	0.3	10	1.9
Comp. Health	106	9.4	54	9.1	52	9.7
Corp.Health Resources	2	0.2	1	0.2	1	0.2
CocaCola	64	5.7	27	4.5	37	6.9
Colonial Webb	1	0.1	1	0.2	0	0
Colortree	18	1.6	11	1.8	7	1.3
CSX	172	15.2	113	19	59	11
DuPontZytel	31	2.7	14	2.3	17	3.2
Dominion VA Power	9	0.8	2	0.3	7	1.3
FD Thomas	27	2.4	18	3	9	1.7
Fed.Marine Terminal	4	0.4	2	0.3	2	0.4
Greyhound	1	0.1	1	0.2	0	0
GRTC	4	0.4	4	0.7	0	0
Heartland	2	0.2	2	0.3	0	0
HTI (UPS)	63	5.6	21	3.5	42	7.8
Industrial Alloy	13	1.1	12	2	1	0.2
Infineon	19	1.7	10	1.7	9	1.7
Mafco Worldwide	14	1.2	11	1.8	3	0.6
Martin Marietta	5	0.4	2	0.3	3	0.6
MEPS	1	0.1	1	0.2	0	0
Shoosmith	1	0.1	1	0.2	0	0
Southern Graphics	55	4.9	35	5.9	20	3.7
Schenker Logistics	4	0.4	0	0	4	0.7
Sumitomo Marine MGMT.	1	0.1	1	0.2	0	0
The HON Co.	9	0.8	9	1.5	0	0
Ukrops	1	0.1	1	0.2	0	0
USPS	1	0.1	1	0.2	0	0
VCU Life EVAC	4	0.4	1	0.2	3	0.6
Vanguard Plastics	1	0.1	1	0.2	0	0
VNG/VANG	81	7.2	33	5.5	48	9
Wako Chemicals	23	2	13	2.2	10	1.9
West End Printing	15	1.3	10	1.7	5	0.9
Total (N = 43)	1132	100	596	100	536	100

TABLE 3. Prevalence of Hearing Loss with Associated 95% C.I.

VARIABLE	TOTAL N	H.L. N	PREVALENCE %	95% C.I.
Gender				
Male	1003	558	55.6	52.5, 58.7
Female	129	38	29.5	21.9, 38.2
Race				
Black/African American	429	201	46.9	42.1, 51.7
White	541	298	55.1	50.8, 59.3
Hispanic	135	82	60.7	51.9, 68.9
Other	27	15	55.6	35.6, 74.0
Age				
<30	192	39	20.3	15.0, 26.8
30-39	292	100	34.2	28.9, 40.0
40-49	357	217	60.8	55.5, 65.8
50+	291	240	82.5	77.5, 86.6
Currently Experiencing Noise in the ears				
yes	107	97	90.7	83.1, 95.2
no	969	470	48.5	45.3, 51.7
Currently Experiencing Dizziness				
yes	22	15	68.2	45.1, 85.3
no	1047	544	52	48.9, 55.0
Currently Experiencing Pain in the Ears				
yes	15	12	80	51.4, 94.8
no	1042	544	52.2	49.1, 55.3
Currently Experiencing Sudden Rapid Hearing Loss				
yes	15	12	80	51.4, 94.8
no	1041	546	52.4	49.4, 55.5
Currently Experiencing Ear Infection				
yes	30	22	73.3	53.8, 87.0
no	1031	536	52	48.9, 55.1
Family History of Hearing Loss				
yes	77	49	63.6	51.8, 74.1
no	904	479	53	49.7, 56.3
Military Service				
yes	290	169	58.3	52.4, 64.0
no	742	375	50.5	46.9, 54.2

TABLE 3. Prevalence of Hearing Loss with Associated 95% C.I. Con't.

VARIABLE	TOTAL N	H.L. N	PREVALENCE %	95% C.I.
Use of Hearing Protection in High Noise Areas				
yes	737	405	55	51.3, 58.6
no	158	80	50.6	42.6, 58.6
Past Medical History of Childhood Diseases				
yes	309	157	50.8	45.1, 56.5
no	822	439	53.4	49.9, 56.9
Measles				
yes	275	190	69.1	63.2, 74.4
no	854	403	47.2	43.8, 50.6
Mumps				
yes	225	156	69.3	62.8, 75.2
no	902	435	48.2	44.9. 51.5
Chicken Pox				
yes	543	274	50.5	46.2, 54.7
no	582	318	54.6	50.5, 58.7
Meningitis				
yes	8	5	62.5	25.9, 90.1
no	1124	591	52.6	49.6, 55.5
Total				
Past Medical History of Large Doses of Antibiotics, Quinine or Aspirin				
yes	51	35	68.6	54.0, 80.5
no	937	491	52.4	49.1, 55.6
Past Noisy Employment				
yes	495	274	55.4	50.8, 59.8
no	512	255	49.8	45.4, 54.2
Past Exposure to Guns				
yes	415	233	56.1	51.2, 61.0
no	593	296	49.9	45.8, 54.0
Participation in a Noisy Hobby				
yes	215	98	45.6	38.8, 52.5
no	806	438	54.3	50.8, 57.8
Smoking Status				
yes	451	234	51.9	47.2, 56.6
no	555	282	50.8	46.6, 55.0

TABLE 4. Prevalence of Hearing Loss by Type of Employer with Associated 95% C.I.

VARIABLE	TOTAL N	H.L. N	PREVALENCE %	95% C.I.
Employer				
AlcanLawsonMardon	16	4	25	8.3, 52.7
Alstom Power	3	1	33.3	1.8, 89.3
Alcoa	166	85	51.2	43.4, 59.0
AtlanticIndustrial	5	2	40	7.3, 83.7
ATMI	1	0	0	10.8, 102.9
AW Bennett	7	5	71.4	30.3, 95.3
Cap.Reg.Airport	90	41	45.6	35.1, 56.4
Carter Lumber	5	5	100	46.3, 99.8
Central Parking	1	1	100	5.5, 104.8
Chesterfield Co.	35	22	62.9	44.9, 78.0
Church& Dwight	39	15	38.5	23.8, 55.4
City of Hopewell	12	2	16.7	2.9, 49.3
Comp. Health	106	54	50.9	41.1, 60.7
Corp.Health Resources	2	1	50	2.7, 100.8
CocaCola	64	27	42.2	30.2, 55.2
Colonial Webb	1	1	100	5.5, 104.8
Colortree	18	11	61.1	36.1, 81.8
CSX	172	113	65.7	58.0, 72.7
DuPontZytel	31	14	45.2	27.8, 63.7
Dominion VA Power	9	2	22.2	3.9, 60.1
FD Thomas	27	18	66.7	46.0, 82.8
Fed.Marine Terminal	4	2	50	9.2, 92.0
Greyhound	1	1	100	5.5, 104.8
GRTC	4	4	100	39.6, 100.0
Heartland	2	2	100	19.8, 101.3
HTI (UPS)	63	21	33.3	22.3, 46.4
Industrial Alloy	13	12	92.3	62.1, 99.8
Infineon	19	10	52.6	29.5, 74.8
Mafco Worldwide	14	11	78.6	48.8, 94.4
Martin Marietta	5	2	40	7.3, 83.7
MEPS	1	1	100	5.5, 104.8
Shoosmith	1	1	100	5.5,104.8
Southern Graphics	55	35	63.6	49.5, 75.9
Schenker Logistics	4	0	0	2.4, 61.7
Sumitomo Marine MGMT.	1	1	100	5.5, 104.8
The HON Co.	9	9	100	62.9, 99.6
Ukrops	1	1	100	5.5, 104.8
USPS	1	1	100	5.5, 104.8
VCU Life EVAC	4	1	25	1.3, 79.2
Vanguard Plastics	1	1	100	5.5, 104.8
VNG/VANG	81	33	40.7	30.1, 52.2
Wako Chemicals	23	13	56.5	34.9, 76.2
West End Printing	15	10	66.7	38.7, 87.1

TABLE 5. Prevalence Ratios of Demographic and Lifestyle Factors and Hearing Loss

VARIABLE	H.L.* N	TOTAL N	PR** (crude)	95% C.I.
Gender				
Male	558	1003	1.9	1.4, 2.6
Female	38	129	1	--
Race				
Black/African American	201	429	1	--
White	298	541	1.2	1.0, 1.4
Hispanic	82	135	1.3	1.0, 1.7
Other	15	27	1.2	0.7, 2.0
Age				
19-30	43	211	1	--
31-40	107	297	1.7	1.2, 2.4
41-50	227	362	3	2.1, 4.2
50-hi	219	262	4.1	2.9, 5.7
Currently Experiencing Noise in the ears				
yes	97	107	1.9	1.5, 2.3
no	470	969	1	--
Currently Experiencing Dizziness				
yes	15	22	1.3	0.8, 2.2
no	544	1047	1	--
Currently Experiencing Pain in the Ears				
yes	12	15	1.5	0.9, 2.7
no	544	1042	1	--
Currently Experiencing Sudden Rapid Hearing Loss				
yes	12	15	1.5	0.9, 2.7
no	546	1041	1	--
Currently Experiencing Ear Infection				
yes	22	30	1.4	0.9, 2.2
no	536	1031	1	--
Family History of Hearing Loss				
yes	49	77	1.2	0.9, 1.6
no	479	904	1	--
Military Service				
yes	169	290	1.2	1.0, 1.4
no	375	742	1	--

* Hearing Loss **Prevalence ratio (crude)

TABLE 5. Prevalence Ratios of Demographic and Lifestyle Factors and Hearing Loss Con't.

VARIABLE	H.L.* N	TOTAL N	PR** (crude)	95% C.I.
Use of Hearing Protection in High Noise Areas				
yes	405	737	1.1	0.9, 1.4
no	80	158	1	--
Past Medical History of Childhood Diseases				
yes	157	309	1	0.8, 1.1
no	439	822	1	--
Measles				
yes	190	275	1.5	1.2, 1.7
no	403	854	1	--
Mumps				
yes	156	225	1.4	1.2, 1.7
no	435	902	1	--
Chicken Pox				
yes	274	543	1.1	0.9, 1.3
no	318	582	1	--
Meningitis				
yes	5	8	1.2	0.5, 2.9
no	591	1124	1	--
Past Medical History of Large Doses of Antibiotics, Quinine or Aspirin				
yes	35	51	1.3	0.9, 1.8
no	491	937	1	--
Past Noisy Employment				
yes	274	495	1.1	0.9, 1.3
no	255	512	1	--
Past Exposure to Guns				
yes	233	415	1.1	0.9, 1.3
no	296	593	1	--
Participation in a Noisy Hobby				
yes	98	215	0.8	0.7, 1.0
no	438	806	1	--
Smoking Status				
yes	234	451	1	0.9, 1.2
no	282	555	1	--

* Hearing Loss **Prevalence ratio (crude)

TABLE 6. Association of Demographic and Lifestyle Factors and Hearing Loss

VARIABLE	H.L.* N	TOTAL N	CRUDE PR**	CRUDE 95% C.I.	ADJUSTED PR**	ADJUSTED 95% C.I.
Gender						
Male	558	1003	1.9	1.4, 2.6	1.7	1.1, 2.6
Female	38	129	1	--	1	--
Race						
Black/African American	201	429	1	--	1	--
White	298	541	1.2	1.0, 1.4	1.1	0.9, 1.4
Hispanic	82	135	1.3	1.0, 1.7	1.2	0.9, 1.6
Other	15	27	1.2	0.7, 2.0	1.2	0.6, 2.4
Age						
19-30	43	211	1	--	1	--
31-40	107	297	1.7	1.2, 2.4	1.7	1.1, 2.7
41-50	227	362	3	2.1, 4.2	2.9	1.9, 4.5
50-76	219	262	4.1	2.9, 5.7	3.7	2.4, 5.8
Currently Experiencing Noise in the ears						
yes	97	107	1.9	1.5, 2.3	1.5	1.2, 2.0
no	470	969	1	--	1	--
Family History of Hearing Loss						
yes	49	77	1.2	0.9, 1.6	1.1	0.8, 1.5
no	479	904	1	--	1	--
Military Service						
yes	169	290	1.2	1.0, 1.4	1	0.8, 1.2
no	375	742	1	--	1	--
Measles						
yes	190	275	1.5	1.2, 1.7	0.9	0.7, 1.2
no	403	854	1	--	1	--
Mumps						
yes	156	225	1.4	1.2, 1.7	1	0.8, 1.4
no	435	902	1	--	1	--
Past Medical History of Large Doses of Antibiotics, Quinine or Aspirin						
yes	35	51	1.3	0.9, 1.8	1.2	0.8, 1.7
no	491	937	1	--	1	--
Past Exposure to Guns						
yes	233	415	1.1	0.9, 1.3	1.1	0.9, 1.3
no	296	593	1	--	1	--
Participation in a Noisy Hobby						
yes	98	215	0.8	0.7, 1.0	1	0.7, 1.3
no	438	806	1	--	1	--
Smoking Status						
yes	234	451	1	0.9, 1.2	1	0.8, 1.2
no	282	555	1	--	1	--

* Hearing Loss **Prevalence ratio

TABLE 7. Association of Demographic and Lifestyle Factors and Hearing Loss and Chemical Exposure

VARIABLE	TOTAL N	CRUDE PR**	CRUDE 95% C.I.	ADJUSTED PR**	ADJUSTED 95% C.I.
Gender					
Male	374	1.6	0.9, 2.7	1.7	0.7, 4.0
Female	43	1	--	1	--
Race					
Black/African American	149	1	--	1	--
White	216	1.2	0.9, 1.6	1.1	0.7, 1.7
Hispanic	40	1.2	0.7, 1.9	1.2	0.7, 2.1
Other	12	1.3	0.6, 2.9	1	0.2, 4.8
Age					
19-30	92	1	--	1	--
31-40	121	1.7	1.0, 2.9	1.8	0.9, 3.5
41-50	129	2.8	1.7, 4.6	2.5	1.2, 5.0
50-76	74	3.7	2.2, 6.3	3.1	1.5, 6.6
Currently Experiencing Noise in the ears					
yes	35	2.1	1.5, 3.1	1.9	1.1, 3.2
no	355	1	--	1	--
Family History of Hearing Loss					
yes	23	1.5	0.9, 2.5	1.3	0.7, 2.4
no	275	1	--	1	--
Military Service					
yes	114	1.1	0.7, 1.5	0.9	0.6, 1.4
no	236	1	--	1	--
Mumps					
yes	63	1.5	1.1, 2.2	1.1	0.7, 1.7
no	352	1	--	1	--
Past Medical History of Large Doses of Antibiotics, Quinine or Aspirin					
yes	14	1.1	0.5, 2.3	1.2	0.6, 2.7
no	301	1	--	1	--
Past Exposure to Guns					
yes	145	1.1	0.8, 1.6	1.2	0.8, 1.7
no	191	1	--	1	--
Participation in a Noisy Hobby					
yes	86	0.7	0.5, 1.1	0.9	0.5, 1.5
no	256	1	--	1	--
Smoking Status					
yes	171	0.9	0.7, 1.2	1.1	0.8, 1.6
no	220	1	--	1	--
Chemical Exposure					
yes	104	1.3	1.0, 1.8	1.1	0.7, 1.6
no	313	1	--	1	--

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